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Abstract: Comments and reports on synthetic biology often focus on the idea that this field may lead to synthetic life or life forms. Such claims attract general attention because “life” is a basic concept that is understood, interpreted and explained in multiple ways. While these different understandings of life may influence the ethical assessment of synthetic biology by experts and the public, this field might, in turn, influence how academics or the public view life. We suggest in this paper that synthetic biology provides an opportunity to discuss and compare different views and explanations of the world, starting from the concept of life. We argue that a narrow focus on just one interpretation of this concept may be harmful and that people will benefit from being aware of a diversity of understandings of life because they provide answers to different questions. Moreover, the confrontation among views is important for the development of reasoning abilities, and a nuanced view on our world will be useful for integrating scientific findings and their implications into a wider context. At the same time, we should not only consider other understandings of life for our own benefit but also because a moral attitude of respect for and toleration toward others implies permission to express and maintain their views. For these reasons, we suggest that a diversity of views on life should be included in public education and in public engagement events on synthetic biology. Moreover, they should be on the research agenda of technology assessment studies within the ELSA or RRI frameworks.

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Different Understandings of Life as an Opportunity to Enrich the Debate About Synthetic Biology

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Abstract Comments and reports on synthetic biology often focus on the idea that this field may lead to synthetic life or life forms. Such claims attract general attention because “life” is a basic concept that is understood, interpreted and explained in multiple ways. While these different understandings of life may influence the ethical assessment of synthetic biology by experts and the public, this field might, in turn, influence how academics or the public view life. We suggest in this paper that synthetic biology provides an opportunity to discuss and compare different views and explanations of the world, starting from the concept of life. We argue that a narrow focus on just one interpretation of this concept may be harmful and that people will benefit from being aware of a diversity of understandings of life because they provide answers to different questions. Moreover, the confrontation among views is important for the development of reasoning abilities, and a nuanced view on our world will be useful for integrating scientific findings and their implications into a wider context. At the same time, we should not only consider other understandings of life for our own benefit but also because a moral attitude of respect for and toleration toward others implies permission to express and maintain their views. For these reasons, we suggest that a diversity of views on life should be included in public education and in public

engagement events on synthetic biology. Moreover, they should be on the research agenda of technology assessment studies within the ELSA or RRI frameworks.

Keywords Synthetic biology · Biotechnology · Gene technology · Life · Artificial life · World views · Public dialogue · Public engagement · ELSA · RRI

Introduction

Synthetic Biology Provides One of Many Possible Explanations of Life

The techno-science of synthetic biology is expected to influence our future in various ways. As a technology, it could lead to useful applications, for instance, in medicine or the production of biofuels. As a science, synthetic biology is expected to provide knowledge about processes in living organisms, their modes of operation and their origins. Synthetic biology may thus not only influence everyday life through novel applications, but it may also have an influence on how people perceive, view, understand, and explain the world. Indeed, reports on synthetic biology have already initiated discussions on whether synthetic biology leads to synthetic life, under what conditions life would be considered to be synthetic or whether life can be synthetic in the first place [10, 16, 24]. In this commentary, we are concerned with these impacts; we will discuss how society should deal with the influence of synthetic biology on our understanding of life.

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The concept of life around which everything revolves in these debates is of a particular character. It is an everyday concept used in the context of our own biography as well as in the description of our environment. However, it is also a key concept for certain philosophical disciplines (such as philosophy of life and phenomenology) and certain scientific theories with philosophical elements (theories of autopoiesis and biosemiotics). Finally, it is the declared object of the life sciences, which although usually not explicitly referring to life, are said to investigate the scientific aspects of life. We speak of different “understandings” of life in order to refer to this variety. These understandings are based on different worldviews. They refer to different theories and models in order to explain life, and their explanations focus on different aspects of life.¹ Biologists, for instance, usually focus on a list of functional or biological criteria of living organisms [26]. In contrast, the philosophical discipline of phenomenology is interested in our perception and appreciation of life as a phenomenon [34] and the ethical position of biocentrism discusses the question of moral value in all living organisms [1, 14]. In light of this diversity, one may wonder whether it is justified to speak of one and the same concept of life. We think this is justified; the reference to the term life in the different understandings discussed here is not a simple equivocation. Representatives of the different views on life mostly agree on which entities are alive.² Because these positions focus on *different* aspects and questions concerning the same subject, the majority of understandings of life are compatible. A scientific explanation concerning the functioning of the processes in living organisms is compatible with a phenomenological explanation about the appearance of living organisms and our perception of them. Even religious understandings of life as a gift from God are compatible with biological explanations of living

organisms. If, however, a position explicitly dismisses background assumptions of another position, this leads to mutually exclusive explanations, for instance, if creationists deny evolution or a reductionist scientist denies the possibility of a supernatural being.

More than researchers in most other types of biology, synthetic biologists like to emphasize that they wish to contribute to the understanding of life [15]. In many commentaries on synthetic biology, the authors point out that this field will change how we see life. Craig Venter, for instance, famously commented that his findings were an important step, scientifically and philosophically, that had changed his view not only on how life works but also on how it is to be defined [35]. The claims of synthetic biology could thus influence nonscientific views on life. Even in the field’s early days, the authors of a commentary article noted that one should consider the questions of “how work on minimal genomes and the creation of new free-living organisms change how we frame ideas of life and our relationship to it” [8]. Other commentators suggested that synthetic biology does, or will in the future, show that there is no “mystery” in life or that it will end the debate about the nature of life [6]. According to these authors, synthetic biology can show that nonscientific approaches to explaining life are wrong or useless.

The aim of this article is neither to criticize the understanding of life in synthetic biology nor to question its validity or importance. We suggest that scientific explanations of life, and the new turn synthetic biology gives these views, ought to be integrated into a wider context. We attempt to show here that it is important to consider and propagate at least some other understandings of life instead of dismissing them as “nonscientific.”

We will argue that different understandings of life should be propagated, because people can gain from a variety of views. Nonbiological views on life can, for instance, allow individuals to address questions that science cannot address. Moreover, it is of educational value to be confronted with a variety of different views. The restriction to one narrow view on the world may be harmful because important aspects may be overlooked. In addition, a respectful and tolerant attitude toward others requires giving them the opportunity to both be confronted with multiple views on the world and to hold and express their own views and interpretations. We will argue that this applies even if some of these views may be less well founded than others or if they are based on

¹ We do not refer to the discrepancy in different understandings of life, which have to do with the fact that some positions speak of life as the property, activity, or phenomenon that is shared by all living organisms whereas others speak of life in a biographical sense as the life-history of a self-conscious being. We are only concerned here with positions that speak of life in the first sense. A special issue of the journal *Worldview* 17 [16, 34] introduces a set of different understandings of life in that sense and discusses how they influence the assessment of synthetic biology.

² Exceptions to this general “agreement” include entities, such as viruses, erythrocytes, or spermatozoa, for which there are different opinions on whether they should count as “alive.”

religious beliefs, which many do not share. On this basis, we will suggest that the diversity of views on and explanations of life ought to be considered in public engagement and education efforts and in the research agenda of synthetic biology Ethical Legal and Social Aspects (ELSA)³ projects.⁴ Finally, we raise the concern that the transition from ELSA to Responsible Research and Innovation (RRI) may run the risk of complicating the inclusion of different worldviews into research on societal, ethical, and philosophical implications of synthetic biology or other biotechnologies.

Basic Concepts Have Been Important in the Debate About Genetically Modified Organisms

The influence of synthetic biology on the understanding of life presents only one side of the relation between the basic concept of life and biotechnologies. It is not only the technologies that influence how we see life but also existing views on life that may influence how a technology is assessed. Using the example of agricultural biotechnology, we briefly illustrate in the following that underlying understandings of basic concepts are relevant in debates about emerging technologies.

The so-called genetic modification (GM) debate has been dominated by concerns about potential risks and benefits of GM organisms to the environment, human health, economy, and society. Besides, as well as together with, these risk-related issues, concerns about the potential violation of the intrinsic value of modified organisms [3, 37] and the unnaturalness of GM have often been expressed by the public [20, 39]. Among academics and other experts too, these issues have caused controversy [22]. Concerns about an intrinsic value of living organisms and the unnaturalness of this technology express specific understandings of the basic concepts of life and nature.

The idea that living organisms have an intrinsic value that may be infringed upon by GM implies that living organisms, unlike other “things,” have moral standing.

³ American authors often use the acronym Ethical Legal and Social Implications/Issues (ELSI) for the same type of research. Since the first ELSA/ELSI research program of the human genome program has been launched, many developments of emerging technologies, particularly in the life sciences, have been accompanied by ELSA research programs.

⁴ In that sense, we support a point made by Philip Ball in an earlier article in this journal, namely, that we need to know more about different preconceptions and images of life and nature in order to be able to understand the public discourse on synthetic biology [2].

Some proponents of this view explicitly worry that GM may lead to conceptual reductionism (cf. [11, 27]) or genetic determinism (cf. [4]). Concerns about reductionism represent a fundamental critique of the materialistic worldview and of the treatment of living organisms only as a means to the end. Such critiques have been brought forward by experts in the academic debate [22] as well as by laypersons in the public debate about agricultural biotechnology [20].

The other basic concept that has played an important role in this debate is that of nature. Concerns about the unnaturalness of GM are frequently brought forward to show that gene technology is morally unacceptable, for instance, because it is against the “autonomy of nature” [25], contrary to a given “natural order” [30] or a contradiction to the “natural aim” of nature [29]. In the 2002 Eurobarometer survey, 58 % of participants felt that modern biotechnology has upset the balance of nature and 65 % felt that GM food threatens the natural order of things [20]. Concerns about naturalness are based on certain understandings of nature, which imply, for instance, a desire for a world untouched by humans [18].

As a biotechnology that explicitly aims to produce new life forms instrumental to human purposes, it can be expected that many of these concerns will also be raised in the context of synthetic biology. This debate will be shaped and driven by novel circumstances, such as the novel technical possibilities and increased “depth of intervention” associated with this field. However, not only the technological background differs but so too do new envisaged applications, a different historical context, current discussions of environmental issues and a novel view on technology driven by digital technology. Finally, the very conclusions and experiences that all sides have drawn from the GM debate provide an entirely different background for the discussions on synthetic biology.

Benefiting from Different Approaches to Explaining Life

The clash of different understandings of basic concepts, such as life and nature, in the GM debate is generally considered objectionable and unwanted. This judgment makes sense with respect to the emotional outbursts and mutual lack of understanding that have characterized this debate. However, with respect to the basic questions of what we mean by life or nature an exchange of views

can be regarded as desirable. In this section, we establish three reasons why a diversity of well-founded approaches to explain life is important and worthwhile.

Science Cannot Address All Questions About Life

When synthetic biologists explain why they can contribute to the understanding of life, they like to quote the saying that is ascribed to Richard Feynman: “what I cannot create I do not understand” [7, 38]. Along these lines, synthetic biology can indeed provide interesting insight into how living organisms operate, about the role of central biochemical components and the functioning of the metabolism or regulatory mechanisms. However, there are other questions about life: is there value or meaning in life, and if so, what is this value or meaning and where does it come from? Such questions are, for instance, systematically addressed by ethics and philosophy in general. These fields deal with aspects of life, such as value or meaning, that are not covered by science and that cannot be investigated using scientific methods [17]. As indicated above, philosophical and scientific explanations usually do not exclude each other; most philosophers consider scientific findings in their theories about life. In that sense, synthetic biology may inform philosophy, but it cannot replace philosophy. Questions about value or meaning in life have occupied humans for several thousand years. For a comprehensive understanding of life, it is important to get to know different approaches to explaining life.

At first sight, this plea for a diversity of understandings of life may sound like an appeal to relativism, according to which all the possible views on life are equally true. However, to argue that the diversity of understandings of life should be acknowledged is not to say that any notion about life should be taken equally seriously. Instead, it means that each explanation of life should be compared with other explanations that address the same type of questions and that it should be assessed within its own theoretical and methodological framework. This is to say that, for instance, vitalist claims about a nonphysicochemical force, which is said to be responsible for biological processes, can be refuted by sciences such as synthetic biology. In contrast, phenomenological claims about how we perceive and interpret living organisms and about the significance of the phenomenon or concept of life for humans cannot be approached or assessed by scientific methodology; instead, such claims need to be justified or criticized using

philosophical arguments [17]. In philosophy, this will often not result in an outright rejection and disappearance of a position but in a controversial discussion, in which arguments for and against a position are brought forward. If a position receives thorough attention and acceptance by philosophical experts and brings up elements that may be interesting and relevant for a general understanding of life in the public, such a view should be introduced to the public. A well-known example, which also brings us back to the point that science cannot address all questions about life, is the position of biocentrism [1, 14]. As discussed in the context of the GM debate, many people have the intuition that living things should be treated differently from nonliving matter. To hear how philosophers argue *for* and *against* an intrinsic value to living beings will result in better founded views on the value of life, an aspect of life that cannot be addressed by science.

Techno-Scientific Expertise Imperialism Should Be Avoided

Pivotal achievements of modern Western societies such as the development of medicine and technology are based on modern science. It is thus unsurprising that in these societies, scientific approaches to explaining the world are predominant. If uncertainties arise, natural scientists are called in as experts. It is often overlooked that some of the questions on core concepts such as life are actually not scientific questions, and natural scientists are not the competent experts. Alan Buchanan’s phrase “expertise imperialism” may be applied here. He used this phrase to refer to a tendency to exaggerate the domain of physicians’ expertise. He explained that whereas physicians are indeed experts with respect to the medical details of a patient’s illness, they are not experts on what it means for a specific patient to lead a good life. Appealing to their expertise in one field they often act as, or are considered to be, experts also in the other [5]. If synthetic biologists are perceived and act as the only experts with respect to explanations of life, their expertise in science is unwarrantedly extended to other fields to which it does not apply such as philosophy. One could thus speak of a type of “techno-scientific expertise imperialism”. Purely scientific approaches to explaining life and the world may result in narrow-minded doctrines, which may lead to problematic morally relevant beliefs. The understanding of living organisms as machines, for instance, might make people

overlook that animals can suffer. A one-sided view on life and on the world in general could thus have the effect that relevant philosophical or moral aspects are disregarded.

The Confrontation with Other Approaches to Explaining the World Is of Educational Value

In the two preceding sections, we established that a diversity of understandings of life ought to be supported, because this allows us to address a broader range of questions and avoids expertise imperialism and the disregard of important aspects. These points have in common that they call for different explanations of life, because by collecting the information provided by the different fields, we know more. In that sense, there is educational value to a diversity of explanations of life because one aim of education is to increase knowledge, but the diversity of explanations of life also has educational value for other reasons. Different views on life express different values and different interpretations. As the nineteenth century philosopher John Stuart Mill famously elaborated in his essay “On Liberty,” the confrontation with such differences encourages the questioning of one’s own views and the identification of underlying reasons, interpretations, and values that might be relevant to one’s view [31]. This may raise novel ideas and help to sharpen one’s argumentation and to put it into a wider perspective. In that sense, one may also gain from, for instance, religiously inspired views, which one might consider to be false, because one does not share the underlying beliefs. In the humanities, the awareness of multiple interpretations and the ability to justify and confine one’s own argumentation are indispensable for good academic practice. Nevertheless, such a confrontation with other views also ought to be part of general education, because everybody benefits from a wider and more nuanced view.⁵

To be confronted with other approaches is thus personally enriching and a precondition for developing reasoning abilities. It has even been suggested that reasoning is one of six core dimensions of well-being, which have to be secured in a socially just system. In such a system, it is necessary to give people the opportunity to develop their reasoning abilities ([33]: 19). Therefore, education should not only provide

information but also train students how to deal with different types of information. To discuss and examine how different explanations of life relate to each other, what arguments in the synthetic biology debate are based on which understanding of life, why some of these views are for some people more convincing than others and where there are overlaps, could serve as a prime example of how to develop and cultivate reasoning abilities.

Moral Attitudes Toward Those Holding Other Views on Life

We have explained why a society and its members can benefit from a diversity of views on and interpretations of life and why a restricted view may be harmful. In the following, we will not focus on potential *consequences* of a narrow view but instead attempt to capture what constitutes a respectful and tolerant *attitude* toward those who hold views on life different from one’s own. For many, purely biological descriptions of life—although mainstream in many contexts in modern societies—are not exhaustive. We point out here that the implementation of important moral principles such as respect, toleration, and the right to freedom of opinion and expression requires allowing holders of multiple views on life to maintain, express, discuss, and propagate their views. This proposition may seem to be evident to some readers, but in various discussions with others, we have realized that there is a risk that “tolerating different views” is equated with relativism or equal support for all views. In this section, we want to explain why this equalization is not correct.

Respecting Personal Autonomy Includes Providing Access to Different Types of Information

Respect for other people is a basic moral attitude that is expected of each member of democratic societies because being respected is important for human well-being. Respect⁶ is due to each human being and includes regarding and treating him or her as a source of moral worth and dignity ([33]: 22). To be respected in this

⁵ Anthony Kronman made a similar point in the context of racial and ethnic diversity in education in the USA: ([28]: 875)

⁶ Stephen Darwall distinguishes between recognition respect, which is owed to all people and appraisal respect which is granted to appraise specific merits and of which thus not everybody is equally worthy [12]. In our context, we focus on recognition respect.

sense means for persons to be able to act according to their own motives and reasons. Therefore, respecting persons includes respecting their autonomy.⁷ In bioethics, respecting autonomy is a central principle, which is famously explained in the Belmont report:

“To respect autonomy is to give weight to autonomous persons’ considered opinions and choices while refraining from obstructing their actions unless they are clearly detrimental to others. To show a lack of respect for an autonomous agent is to repudiate that person’s considered judgments, to deny an individual the freedom to act on those considered judgments, or to withhold information necessary to make a considered judgment, when there are no compelling reasons to do so.” ([40]: 5)

This statement was made with regard to the medical context and has led to a particular emphasis on the importance of informed consent. Autonomy can, however, also be transferred to our context—how to deal with different explanations of the central concept of life in the synthetic biology debate. The quotation states that to be autonomous means to be exposed to all the information that is needed to make considered judgments. In the medical context, this remark is mostly related to factual information about the disease and potential treatments. However, information that is required to form considered judgments not only includes facts necessary to make informed medical decisions but also background information required for the development of a nuanced personal position. To be autonomous thus implies being exposed to different perspectives. Thomas Scanlon elaborates a political version of this understanding of autonomy in his theory of freedom of expression. He maintains that a state is never entitled to repress freedom of expression on the grounds that false beliefs would be propagated and that people might cause harmful consequences in acting upon these false beliefs. Scanlon claims that agents are only autonomous if they have the option to compare different arguments and judge for themselves

which they consider being false and which should be action-guiding for them. Furthermore, he argues that agents must be allowed to act upon their personal beliefs, even if consequences are harmful [36]. Applied to our context, empowering persons to make use of their autonomy means to confront them with different views on life. This will allow them to develop a personal understanding and interpretation of this concept, which can serve as a basis for opinions on synthetic biology and its applications.

Toleration and Freedom of Opinion and Expression Imply Giving Those Who Hold Other Views a Voice

Toleration too is often understood as a concern for autonomy of others [19]. When we examined the relevance of respect for autonomy, however, we focused on the importance of guaranteeing access to a broad variety of information to allow people to *form* their own views, opinions, and judgments. When we address the attitude of tolerance and the right to freedom of opinion and expression here, we assert that in democratic societies, it is important that people can *maintain* and *express* their views, even if many others do not share them. Warranting the right to freedom of opinion and expression is part of a tolerant attitude. We understand tolerance as an attitude towards people rather than toward the content of their opinions [23], but what does it mean to pay attention to others in the discussion on life in synthetic biology? It has been suggested that freedom of expression implies that everybody ought to have access to expressive opportunities [9]. To warrant expressive opportunities for those who hold different views on life in the debate about synthetic biology means that platforms should be provided that allow for the expression of different views, for instance, in public engagement events or in the media.

Although toleration for others is not based on the requirement that their views are convincing or accessible for us, it does *not* imply that all of these views need to be treated equally. There are views, which although tolerated as views of individuals, will not be considered enriching or important. Examples of such views are views that rest on faulty argumentation or are incompatible with basic norms and moral standards of democratic societies such as human rights. For instance, a eugenic theory about human life distinguishes between more and less desirable biological forms of human life. Such a view can be interpreted as suggesting that humans

⁷ Because we are discussing what it means to act respectfully of others in the context of different understandings of life, we focus on respect for autonomous *persons*. This is not to say that human beings who are no persons (such as young children) ought not to be respected, but respecting them does not imply warranting that they can maintain, express and propagate their specific views on and interpretations of life.

should be treated differently according to their biological properties. This is not compatible with the principle of equal rights for all human beings. There are strong moral reasons not to support such a view beyond tolerating it as a problematic opinion of certain individuals who do have freedom of opinion and expression.⁸ Warranting a right to freedom of opinion and expression and practicing toleration is thus compatible with criticizing and rejecting certain understandings of life and does not force us into relativism.

Different Understandings of Life in the Debate About Synthetic Biology

In the two previous chapters, we argued that the consideration of and confrontation with other views is of great importance. The discussion on synthetic biology suggests itself to implement these conclusions, because with the questions on synthetic life it raises issues that are directly linked to different disciplines and worldviews. In the following, we describe three different strategies for implementation.

First, efforts to inform and train the public ought to include a discussion of different approaches to explaining the world and the relation between these explanations. We have argued that people gain in various ways from being aware of and confronted with different approaches to explaining life. Furthermore, we have suggested that respecting the autonomy of others means that one ought to facilitate their access to the information that is necessary for forming nuanced views on central concepts such as the concept of life. To have such a view will help integrate the aims and claims of synthetic biologists into a wider context and assist us to judge whether, or in what respect, synthetic biology leads to the engineering or synthesis of life.

A general understanding of the differences in interpretations of the concept of life could also support people in dealing with different associations that this concept may have for them. The understanding that different explanations of life may each be well-founded expert views, and

that they are not necessarily mutually exclusive, will help to bring these different associations together. Therefore, public education efforts and media reports should not present natural scientists as the only experts on life. Instead, educationalists and the media also ought to consult philosophers, ethicists, social scientists, theologians, and other experts dealing with the concept of life in order to foster the awareness of the diversity of this concept in the public's views.

Second, public engagement ought to include possibilities for a mutual exchange of views on important concepts, such as the concept of life, which influence the perception of synthetic biology. Following the GM debate, natural scientists and policy makers became aware of the necessity to foster the interaction between natural scientists and other members of society. The early “public understanding of science movement” was based on the idea that the main reason for public opposition to science was the public's lack of knowledge about science. This “deficit model” was then criticized by social scientists. They argued that public education efforts should be replaced by mutual engagement efforts, in which natural scientists listen to the public and where the public's view points, values, and concerns are taken up into the discussion [13, 44]. We do not think that public engagement ought to replace more classical forms of public education, where experts are involved as teachers. Instead, we think the aims and justifications of public engagement differ from those of public education and these should be seen as complementary approaches.

We suggested that a tolerant moral attitude toward our fellow humans implies allowing them to hold and express their views, even if some of us consider those views to be wrong. Scientists are part of society and are influenced by the rest of society; in turn, their work influences views in the rest of society. Scientific views ought thus to be treated as one type among other types of views—with a certain methodological approach to explain natural phenomena.⁹ In order to integrate a new techno-science (such as synthetic biology) with society, it is important that an exchange between natural

⁸ When we speak of tolerating expressions of a proponent of a eugenic theory, this does not include political statements or discriminatory hate speech that directly violates human dignity of others. We exclusively speak of people who support eugenics as a *scientific* principle as it was supported by well-known scientists in the 1960s and 1970s, for instance some of the views expressed at the CIBA Symposium “Man and His Future” 1962 [43].

⁹ Joanna Goven revealed that this important point has been disregarded in New Zealand's Report of the Royal Commission on Genetic Modification. In this report, the commission identified worldviews as the sources of people's values. They mention the traditional Maori worldview, the ecological worldview and the religious worldview but do not take into account that also the rest of society, including scientists themselves, are influenced by a specific worldview with its values [21].

scientists and the rest of society takes place. The aim of a mutual engagement process, as suggested here is not to diminish the impact of synthetic biology but to reflect it from different sides.

Third, research on ethical, legal, and social aspects (ELSA) of synthetic biology ought to address the implications that synthetic biology has on the public's views about life and discuss the role of underlying understandings of life for the perception and assessment of synthetic biology. The impact of synthetic biology on the public's views about life is part of the ethical and social aspects and implications of this field; it should thus be addressed by ELSA research. The role of underlying basic concepts in the GM debate indicates that different understandings of nature or life do play a role in such discussions. More information is needed about the understanding of such basic concepts by the public, of how technological developments influence these concepts and how, in turn, underlying basic concepts may influence the perception of and reaction to synthetic biology and other emerging technologies. Importantly, this relationship between science and technology, on the one hand, and the worldview and values in society, on the other hand, should also remain on the research agenda after the recent shift in the focus of technology assessment from ELSA to RRI. RRI has been a reoccurring phrase in the EU funding initiative Horizon 2020 and also in documents of national research councils for instance in the UK, Norway, and the Netherlands [42]. As indicated by the new label "RRI" the focus lies in the scientific innovation process. The idea is that technology assessment institutions should not only focus on the minimization of risks and negative impacts but also direct the research development process toward aims that take up needs and requests of society under consideration of its central values [32, 42, 45]. Public engagement and participatory approaches are a central element of the RRI strategy; this should warrant the consideration of different points of view. However, with this focus on the innovation process and desired aims, we may risk exclusion of other ethical and societal aspects such as those discussed in this commentary. The responsibility of natural scientists, those who communicate about scientific developments and those who decide, which positions should be represented in public events, goes beyond the consideration of potential risks and the steering of research and innovation towards socially desirable applications. As pointed out here, this responsibility includes modesty with respect to the explanatory

limits of scientific approaches and an effort to discuss the implications that scientific findings and technological developments have on the understanding that people hold of the world and of themselves.

Concluding Remarks

Synthetic biology has so far not triggered strong public opposition and may not do so in the near future [41]. However, as our rationale for communicating and supporting a diversity of views on and explanations of life infers, the aim of avoiding a backlash against synthetic biology should neither be the only nor the main reason for addressing ethical, philosophical, and societal implications of this field or involving the public in these discussions. Nevertheless, the observation that the public currently seems not to be particularly worried about synthetic biology may well shape public engagement and education efforts and ELSA or RRI research. The focus should not *only* be set on risks and benefits of this technology and on informing the public about the scientific background of synthetic biology. Instead, we have argued here that this field might also provide a valuable opportunity to deliberate on different understandings and interpretations of the central concept of life.

A variety of understandings of life provides a remarkable opportunity for enriching the debate about synthetic biology, because all participants in this debate may gain from this diversity in various ways. Moreover, such a debate provides an opportunity to practice moral attitudes, such as respect and tolerance, which are central to a democratic society. An exchange and comparison of different views on life may give the debate about synthetic biology a special meaning and importance that goes beyond preventing conflict or creating acceptance.

This commentary focused on different views on and explanations of the central concept of life in the debate about synthetic biology. The point that we wanted to make, however, is much more general. It concerns the importance of different approaches to explaining basic concepts guiding our understanding of the world such as "nature," "artificiality," "normality," "environment," or "health." This point is not only important in discussions on synthetic biology but also in other

debates on issues that raise fundamental questions about our understanding of the world in which we live.

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Conflict of Interest Anna Deplazes-Zemp, Nikola Biller-Adomo, and Daniel Gregorowius declare that they have no conflict of interest.

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